EXHIBIT 2

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Kahn et al.

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(54) **STEP COUNTER ACCOUNTING FOR INCLINE**

(75) Inventors: **Philippe Kahn**, Aptos, CA (US); **Arthur Kinsolving**, Santa Cruz, CA (US)

(73) Assignee: **DP Technologies, Inc.**, Scotts Valley, CA (US)

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(52) **U.S. Cl.** **235/105**; 702/160; 702/155; 702/158; 482/8; 377/24.2

(58) **Field of Classification Search** 235/105; 702/160; 377/24.2
See application file for complete search history.

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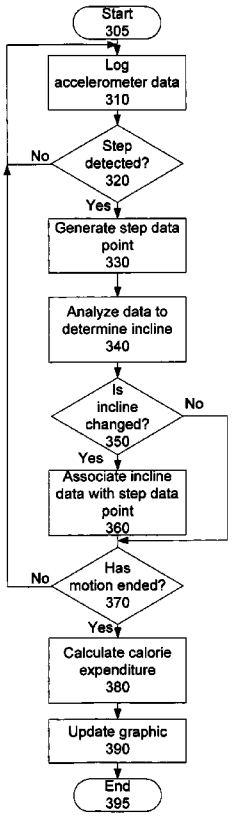
Primary Examiner—Michael G Lee
Assistant Examiner—Suezu Ellis
(74) *Attorney, Agent, or Firm*—Blakely, Sokoloff, Taylor & Zafman, LLP; Judith A. Szepesi

(57) **ABSTRACT**

A method and apparatus for a step counter system is described. The step counter system comprises an accelerometer to detect motion of a user, a step calculation logic to utilize the motion detected by the accelerometer to detect and count steps, and an incline logic to calculate an incline of a surface on which the user moved.

24 Claims, 4 Drawing Sheets



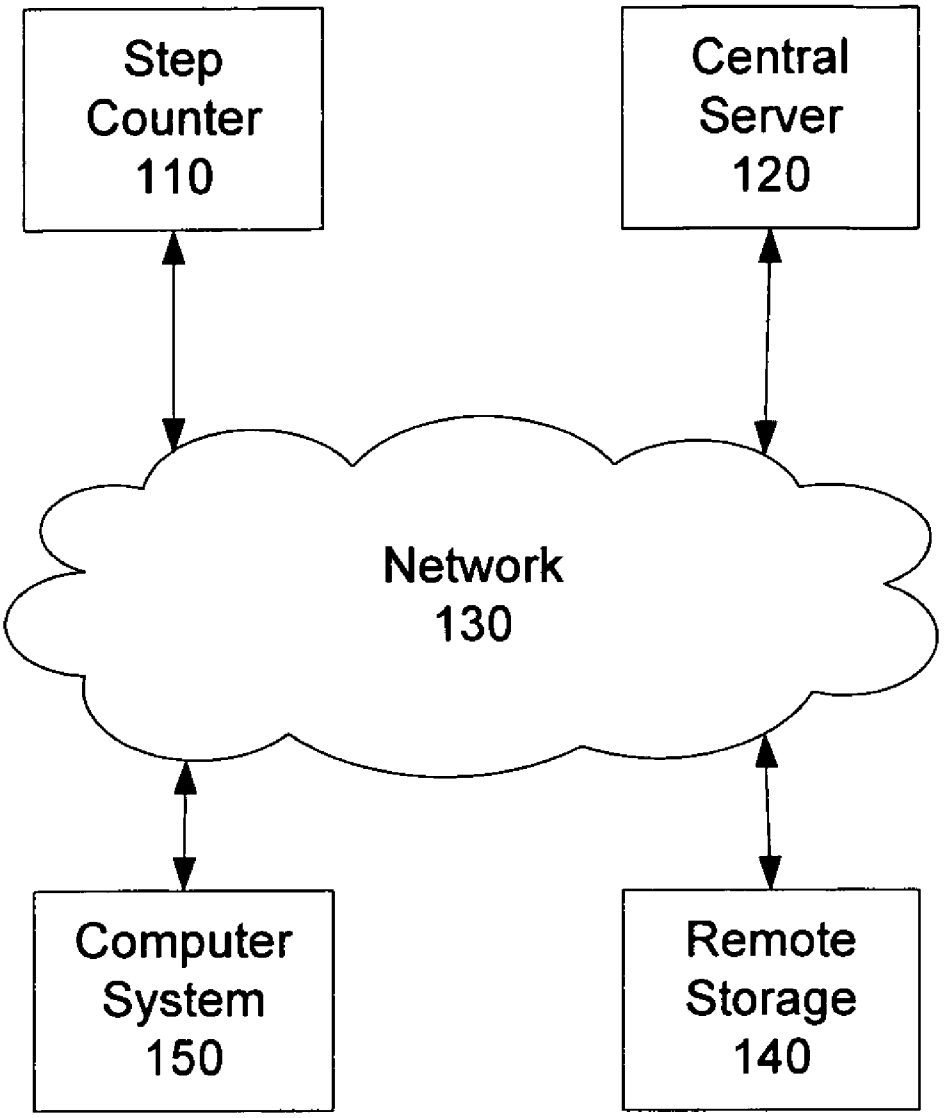

Step Counter 110
Central Server 120
Network 130
Computer System 150
Remote Storage 140

Fig. 1

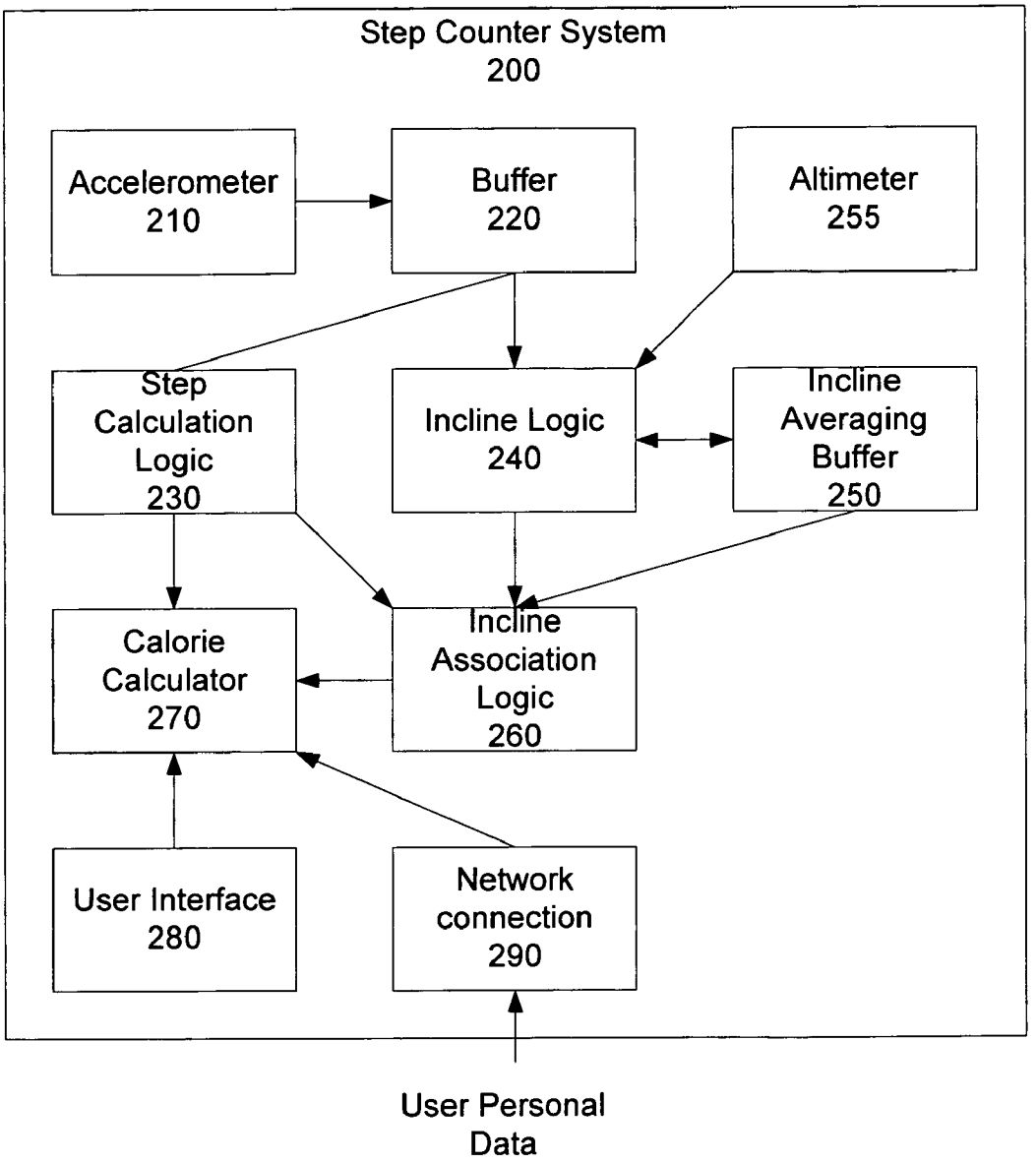

Step Counter System
200
Accelerometer
210
Buffer
220
Altimeter
255
Step
Calculation
Logic
230
Incline Logic
240
Incline
Averaging
Buffer
250
Calorie
Calculator
270
Incline
Association
Logic
260
User Interface
280
Network
connection
290
User Personal
Data

Fig. 2

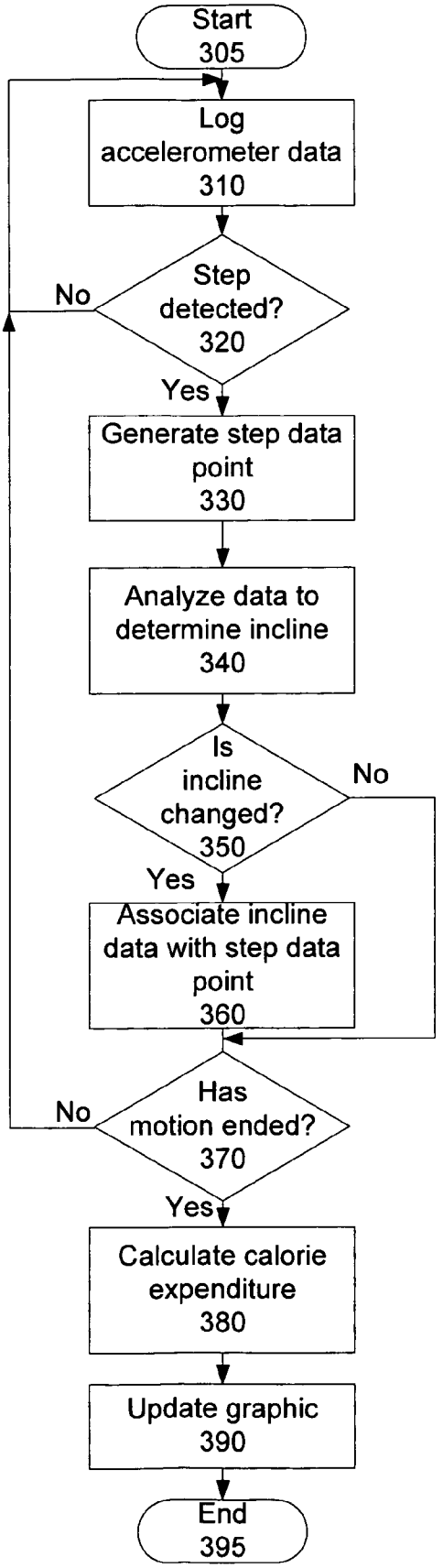

Start
305
Log accelerometer data
310
Step detected?
320
No
Yes
Generate step data point
330
Analyze data to determine incline
340
Is incline changed?
350
No
Yes
Associate incline data with step data point
360
Has motion ended?
370
No
Yes
Calculate calorie expenditure
380
Update graphic
390
End
395

Fig. 3

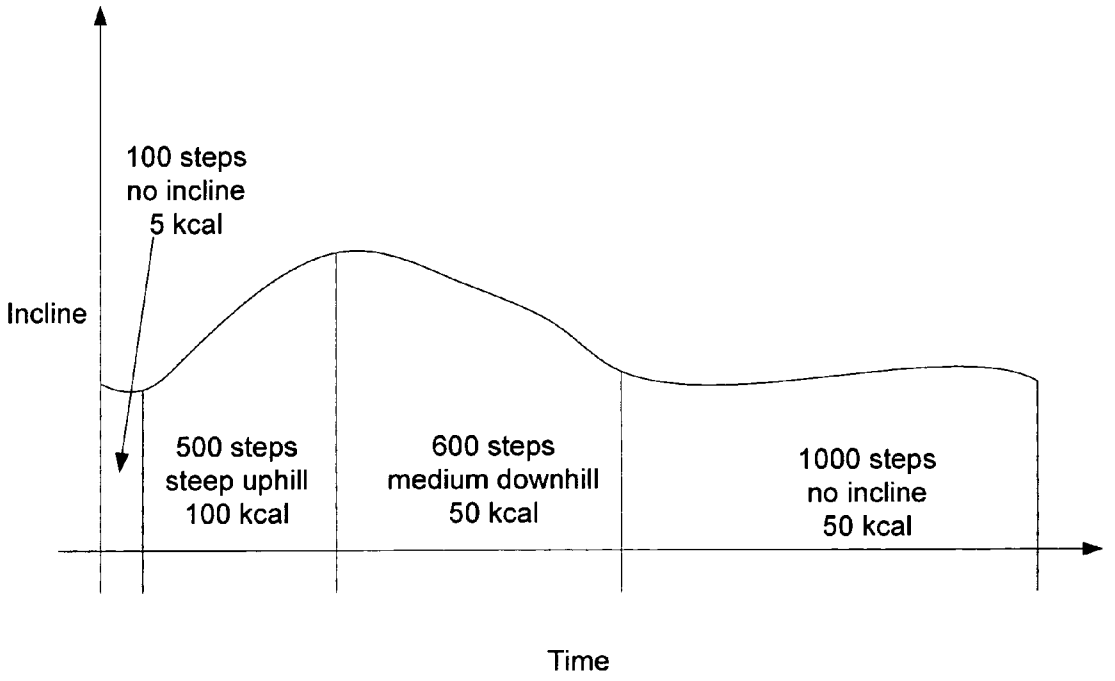

100 steps
no incline
5 kcal
Incline
500 steps
steep uphill
100 kcal
600 steps
medium downhill
50 kcal
1000 steps
no incline
50 kcal
Time

Fig. 4

STEP COUNTER ACCOUNTING FOR INCLINE

FIELD OF THE INVENTION

The present invention relates to step counters, and more particularly to an improved step counter.

BACKGROUND

A step counter is a device that counts each step a person makes. Step counters are becoming popular as means of measuring exercise, and to motivate people to move. Generally, step counters count the number of steps taken during the day. Step counters can give encouragement to improve health. Step counters are increasingly becoming embedded in more and more personal mobile devices such as mobile phones. Some health advocates recommend taking 10,000 steps per day for a healthy lifestyle. Some simple step counters use a mechanical switch to detect steps together with a simple counter while newer step counters use linear accelerometers, also known as inertial sensors, to detect steps. Some step counters attempt to estimate the number of calories a user is burning through taking the counted number of steps. In prior art, these caloric burn estimations are based on a user profile (height, weight and sometimes stride length) and may also take into consideration the walking speed. However, these prior art step counters are not accurate in calculating the amount of calories expended as they do not account for walking on inclines as opposed to flat surfaces. The angle of an incline has a dramatic effect on a user's caloric burn and is not accounted for prior art step counters.

SUMMARY OF THE INVENTION

A step counter comprising an accelerometer to detect motion of a user, a step calculation logic to utilize the motion detected by the accelerometer to detect and count steps, and an incline logic to calculate an incline of a surface on which the user moved.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings and in which like reference numerals refer to similar elements and in which:

FIG. **1** is a block diagram of one embodiment of a network system including the step counter and server.

FIG. **2** is a block diagram of one embodiment of the step counter system.

FIG. **3** is a flowchart of one embodiment of the system.

FIG. **4** is an illustration of one embodiment of the output that may be shown to the user.

DETAILED DESCRIPTION

The method and apparatus described is an improved step counter, or motion calculation system, which provides credit for motion made on the incline. Generally speaking, step counters simply count steps and provide a measurement of the speed at which these steps were taken. However, the incline of the slope on which steps are taken has a substantial effect on the effort required and caloric burn associated with taking the steps. Steps taken on a flat surface are less aerobically intensive than steps taken on an upward incline and thus should be differentiated from one another in an accurate step counter.

Treadmills account for this variation, but step counters do not. The step counter system of the present application accounts for the variation in exercise level based on the incline.

FIG. **1** is a block diagram of one embodiment of a network system including the step counter and server. In one embodiment, a first step counter **110** is coupled via a network **130** to a central server. In one embodiment, the step counter **110** is intermittently coupled to the network **130**. In another embodiment, the step counter **110** may be completely independent. In another embodiment, the step counter **110** may be designed to be coupled to a local computer **150**, which in turn is coupled to the network **130** and through the network to the server **120**.

The central server **120** is a health server for collecting health data. In one embodiment, central server **120** is a general health server designed to collect, correlate, and share health data from multiple monitors, sensors, and devices. The step counter is one such device, which may also include a heart monitor, glucose meter, blood pressure monitor, and others. One embodiment of a central server which may be utilized with the present invention is described in co-pending patent application Ser. No. 11/192,549, filed on Jul. 29, 2005, entitled "Monitor, Control, and Share (MACS) System". In one embodiment, the central server **120** performs some of the calculations, as described below.

In one embodiment, the communication from the step counter **110** to the central server **120** includes step and incline data. In one embodiment, the communication from the central server **120** to the step counter **110** includes personal data of the user, which may be used by the step counter **110** to calculate calorie expenditure of the user. In another embodiment, the central server **120** may perform this calculation. In one embodiment, the central server **120** may transmit the result of these calculations back to the step counter **110**. The split of functionality between the step counter **110** and central server **120** may be arbitrarily defined, except that the step counter **110** obtains the accelerometer data, and in some embodiments other sensor data. As noted above, in one embodiment, the step counter **110** may be completely independent and the server **120** may be absent. In another embodiment, the step counter **110** may simply collect sensor data, and in one embodiment display results, while all calculations are made on the server **120**.

In one embodiment, the step counter **110** may be any mobile device including an accelerometer, which is capable of collecting accelerometer data, and either performing calculations, transmitting accelerometer data to the central server **120**, or both. The central server **120** may perform all of the calculations. In one embodiment, the data may be stored on a remote storage medium **140**, which may be a database or other storage medium. In one embodiment, the remote storage medium **140** may be part of the server **120**. In one embodiment, the remote storage medium may be a distributed storage.

In another embodiment, the step counter **110** may be a dedicated device designed to perform step calculations and incline calculations. In one embodiment, the step counter **110** may be independent of the central server **120**. In one embodiment, if that is the case, the user may separately connect to the central server **120** via computer system **150**, to transfer the step counter data manually.

FIG. **2** is a block diagram of one embodiment of the step counter system. The step counter system **200**'s functionality may be distributed between a server and a client. The step counter system **200** in one embodiment includes an accelerometer **210**. In another embodiment, the accelerometer **210**

may be external to the system, with only accelerometer data being received by the system from the external accelerometer **210**.

The accelerometer data is in one embodiment sent to buffer **220**. The accelerometer data is used by step calculation logic **230** to calculate steps taken by the user. In one embodiment, the calculation system described in co-owned application Ser. No. 11/192,549 is used by step calculation logic **230**.

The accelerometer data is further used by incline logic **240**, to determine an incline associated with a step. A step includes three parts, a vertical travel up, a horizontal travel, and a vertical travel down. The difference between the vertical travel up and the vertical travel down is the incline. In one embodiment, the incline logic **240** calculates the incline for each step. In one embodiment, the system includes an incline averaging buffer **250**, to enable the calculation of an averaged incline. In one embodiment, the system averages the incline over a period of several steps.

In one embodiment, the system may further include an altimeter **255**, or pressure sensor. In one embodiment, the altimeter **255** may be calibrated using network triangulation for a mobile phone based step counter system **200**. In one embodiment, if global positioning system (GPS) data is available, it may be used to calibrate the altimeter. The altimeter's output indicates the change in altitude. This information is used, in one embodiment, by incline logic **240** to determine the incline. In one embodiment, the data from the altimeter **255** and accelerometer **210** are used in combination to get a more accurate measurement of the slope. The combination provides an accurate measurement of the incline. Knowing that an object is moving and quantifying how it is moving helps in determining whether pressure changes sensed by the altimeter **255** are due to changes in altitude or weather. Furthermore, changes in pressure as detected by the altimeter **255**, while a device is in motion, will help more accurately describe the motion of the object and, specifically, the change in altitude.

Incline association logic **260** adds the incline data to each step data. In one embodiment, step calculation logic **230** outputs only a step count, rather than the step data. In one embodiment, the incline association logic **260** associates an initial incline level with the data. The incline association logic **260** then associates a delta (i.e. change in incline) with following steps. This reduces the amount of data used when the user walks on a consistent incline for a period. In another embodiment, an actual incline level is associated with each step. In another embodiment, an incline average is calculated by incline association logic **260**, over an exercise period, and only the average is associated with the data. In another embodiment, a new incline is calculated and associated with the data whenever the user's walking cadence changes. In general, users change their cadence when the road incline changes by a significant percentage.

In one embodiment, calorie expenditure calculator **270** calculates a user's calorie expenditure based on the step and associated incline data. In one embodiment, the calorie expenditure calculator **270** utilizes personal data of the user to calculate the calories expended. The personal data may include one or more of the following: the user's height, the user's weight, the user's heart rate, and the user's stride length. In one embodiment, this data is obtained directly from the user, via a user interface **280**. In one embodiment, this data is obtained from a server, via a network connection **290**. In one embodiment, the system attempts to obtain the data from the server, and whatever data is not available from the server is obtained from the user via user interface **280**.

In one embodiment, the user interface **280** may be used to display to the user his or her calorie expenditures. FIG. **4** illustrates one example of an output which may be presented to the user. As can be seen, the output includes a graph illustrating the overall incline during the walk. In one embodiment, the output further includes a total calorie count for the walk. In one embodiment, the output actually includes calorie counts for each of the incline segments. This illustrates graphically to the user the differences associated with walking on various inclines. In this way, a more accurate representation of a user's effort may be determined and an accurate estimation of caloric expenditure may be determined. In one embodiment, this display may be available via a web interface. In another embodiment, a simplified version of this display may be available on the mobile device hosting the accelerometer.

FIG. **3** is a flowchart of one embodiment of the system. The process starts, in one embodiment, when the accelerator detects motion. In one embodiment, the accelerometer is continuously monitoring for motion.

At block **310**, accelerometer data is logged. The user's stepping motion may be measured by various types of accelerometers (inertial sensors). A simple inexpensive step counter uses a two-axis accelerometer and requires that the user place the device in a certain position so that the stepping motion can accurately be measured. More advanced step counters use a tri-axis accelerometer to allow the device to measure steps regardless of where the device is placed. Alternatively, the user's motion may be detected by two two-axis accelerometers, or another detection mechanism which provides motion data.

At block **320**, the process determines whether a step has been detected. As noted above, this may be done using the mechanism described in co-pending application Ser. No. 11/192,549, or another mechanism.

If a step has been detected, at block **320**, the process continues to block **330**. Otherwise, the process returns to block **310** to continue collecting accelerometer data.

At block **330**, a step data point is generated. At block **340**, the accelerometer data is analyzed to determine an incline associated with the step. In one embodiment, in addition to using accelerometer data, additional sensor data may be used to more accurately determine the incline. In one embodiment, the additional sensor may be a pressure sensor, or altimeter. In one embodiment, the process continues directly to block **360**, and associates the incline with the step data. In another embodiment, the process continues to block **350**.

At block **350**, the process determines whether the incline has changed from a previously calculated incline. If so, the process continues to block **360**, and the new incline value is associated with the step data. If not, the process continues directly to block **370**.

At block **370**, the process determines whether the motion has ended. If not, the process returns to block **310**, to continue logging acceleration data. If the motion has ended, the process continues to block **380**.

At block **380**, in one embodiment, a calorie expenditure calculation is performed for the user, based on the step data, incline data, and in one embodiment the user's personal data such as weight, height and stride length. In another embodiment, this step may be skipped. In another embodiment, this may happen at a separate time, in an off-line setting.

At block **390**, in one embodiment, a graphical illustration of the user's progress, including the incline data, is created. In another embodiment, this may happen at a separate time, in an off-line setting. In another embodiment, this step may be skipped.

The process then ends at block **395**. In this way, the system utilizes the accelerometer data to provide data about the incline, and the corresponding change in calorie expenditure to the user.

In the foregoing specification, the invention has been described with reference to specific exemplary embodiments thereof. It will, however, be evident that various modifications and changes may be made thereto without departing from the broader spirit and scope of the invention as set forth in the appended claims. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense.

The invention claimed is:

1. A step counter system comprising:
an accelerometer to detect motion of a user;
a step calculation logic to utilize the motion detected by the accelerometer to detect and count steps; and
an incline logic to utilize the motion detected by the accelerometer to make a calculation of an incline of a surface on which the user moved for one or more of the steps, wherein the calculation is performed for a step based on identifying a vertical travel up portion of the step, identifying a vertical travel down portion of the step, and computing a difference between the vertical travel up portion and the vertical travel down portion of the step.

2. The step counter system of claim **1** further comprising a calorie expenditure calculator to calculate a calorie expenditure for the user based on the steps and incline data.

3. The step counter system of claim **2**, further comprising an interface to enable a user to input his or her personal data, the personal data used to calculate the calorie expenditure.

4. The step counter system of claim **3**, wherein the interface comprises a network interface to enable the step counter system to obtain the personal data from a server.

5. The step counter system of claim **3**, wherein the personal data comprises one or more of the following: height, weight, stride length, and heart rate.

6. The step counter system of claim **1**, further comprising:
the incline logic to average inclines calculated for a plurality of steps.

7. The step counter system of claim **1**, wherein each step is associated with a cadence of the user, the step counter system further comprising:
the incline logic to calculate a new incline when the user's cadence changes.

8. The step counter system of claim **1**, further comprising:
an altimeter to determine a change in altitude;
the incline logic to utilize the change in altitude to make an additional calculation of the incline of the surface, and to verify the calculation of the incline using the additional calculation of the incline.

9. A system comprising:
a motion detection apparatus to detect three dimensional motion of a user on a surface;
an incline logic to utilize the motion detected by the motion detection apparatus to make a calculation of an incline of the surface to associate with user steps, wherein the calculation is performed for one or more of the user steps based on identifying a vertical travel up portion of the step, identifying a vertical travel down portion of the step, and computing a difference between the vertical travel up portion and the vertical travel down portion of the step; and
an energy calculation logic to calculate a calorie expenditure of the user, based on the three dimensional motion of the user, wherein the energy calculation logic takes into account the incline of the surface.

10. The system of claim **9**, wherein the motion detection apparatus is an accelerometer, and the accelerometer data is used to calculate the incline of the surface.

11. The system of claim **9**, the system further comprising:
an altimeter to determine a change in altitude;
the incline logic to utilize the change in altitude to make an additional calculation of the incline of the surface and to verify the calculation of the incline using the additional calculation of the incline.

12. The system of claim **9** further comprising further comprising an interface to enable a user to input his or her personal data, the personal data used to calculate the calorie expenditure.

13. The system of claim **12**, wherein the interface comprises a network interface to enable the step counter system to obtain the personal data from a server.

14. The system of claim **9**, interface further comprising:
the incline logic to average inclines calculated for a plurality of steps.

15. The system of claim **9**, wherein the personal data comprises one or more of the following: height, weight, stride length, and heart rate.

16. The system of claim **9**, wherein each step is associated with a cadence of the user, the system further comprising:
the incline logic to calculate a new incline when the user's cadence changes.

17. A method comprising:
receiving data from an accelerometer, the data indicating a motion of a user in three dimensions;
calculating, by a mobile device, user step data based on the accelerometer data; and
calculating an incline by the mobile device, and associating the incline with the step data, wherein for one of more of the steps the incline is calculated by identifying a vertical travel up portion of the step, identifying a vertical travel down portion of the step, and computing a difference between the vertical travel up portion and the vertical travel down portion of the step.

18. The method of claim **17**, further comprising:
detecting a change in altitude using an altimeter; and
utilizing the change in altitude to verify the incline of the surface.

19. The method of claim **17**, further comprising:
calculating a calorie expenditure for the user based on the step data and the incline data.

20. The method of claim **17**, further comprising:
using personal data of the user to calculate the calorie expenditure.

21. The method of claim **20**, further comprising:
connecting to a health server to obtain the personal data about the user.

22. The method of claim **20**, wherein the personal data comprises one or more of: height, weight, stride length, and heart rate of the user.

23. The method of claim **17**, further comprising:
transmitting the accelerometer data to a server for calculations.

24. The method of claim **17**, wherein each step is associated with a cadence of the user, the method further comprising:
calculating a new incline when the user's cadence changes.

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